

# Mechanick Dyalling:

TEACHING

Any Man, though of an Ordinary Capacity and unlearned in the Mathematicks, to draw a True

## SUN-DIAL

On any

## Given Plane,

However scituated : Only with the help of a straight *RULER* and a pair of *COMPASSES*; And without any Arithmetical Calculation.

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By Joseph Moxon, *Hydrographer to the Kings most Excellent Majesty.*

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*Atlas.* MDC LXVIII

and the people of the world

in the year

of the year



# MECHANICK DYALLING.

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## *Description of Dyalling.*

**D***Yalling* originally is a *Mathematical Science*, attained by the Philosophical contemplation of the motion of the Sun, the motion of the Shaddow, the Constitution of the Sphere, the Scituation of Planes, and the consideration of Lines.

## *Explanation.*

**T**HE motion of the Sun is regular, it moving equal Space in equal Time; But the motion of the Shaddow irregular in all parts of the Earth, unless under the two Poles, and that more or less according to the Constitution of the *Sphere* and scituation of the *Plane*. And therefore Scientifick Dyalists by the Geometrick considerations of Lines, have found out Rules to mark out the irregular motion of the *Shaddow* in all *Latitudes*, and on all *Planes*, to comply with the regular motion of the Sun. And these Rules of adjusting the motion of the Shaddow to the motion of the Sun may be called *Scientifick Dyalling*.

But though we may justly account *Dyalling* originally a *Science*, yet such hath been the Generosity of many of its studious Contemplators, that they have communicated their acquired Rules; whereby it is now become to many of the Ingenious no more difficult than an *Art*, and by many late Authors so intituled: Nay more, by this small Treatise it will scarce be accounted more than a *Manual Operation*; for, though (hitherto) all the Authors I have met with seem to presuppose their Reader to understand *Geometry*, and the *projecting of the Sphere* already, or else endeavour in their Works to make him understand them, as if they were absolutely necessary to be known by every one that would make a *Dyal*, when as in truth (the contemplative pains of others aforesaid considered) they are not; but indeed are only useful to those that would know the reason of *Dyalling*. Thus they do not only discourage young beginners, but also disappoint many Gentlemen and others that would willingly either make them themselves, or set their Workmen about them, if they knew how to make them.

This little Piece I have therefore composed for the help of those who understand neither the *Projection of the Sphere*, or *Geometrical Operations*: Only, if they know how to draw a straight Line between two Points by the side of a Ruler, describe a Circle with a pair of Compasses, erect a Perpendicular, and draw one Line parallel to another, they may know how to draw a *Dyal* for any given *Plane*, however situated in any Latitude.

But perhaps these two last little Tricks are not known to all new beginners, therefore I shall shew them. First,

*How*

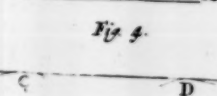
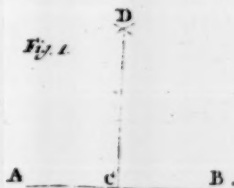


*How to erect a Perpendicular. For Example, in Fig. 1.*

Upon the Line A B you would erect a Perpendicular to the Point C : Place one Foot of your Compasses upon the point C, and open the other to what distance you please ; For *Example*, to the point A, make there a mark ; then keeping the first Foot still in C, turn the other Foot toward B, and make there another mark ; then open your Compasses wider, suppose to the length A B, and placing one Foot in the point A, with the other Foot describe a small Arch over the point C, and removing the Foot of your Compasses to the point B, with the other Foot describe another small Arch, to cut the first Arch, as at D. Then lay your straight Ruler to the point where the two small Arches cut each other, and upon the point C, and by the side of the Ruler draw the Line C D, which shall be a Perpendicular to the Line A B.

*Another way with once opening the Compasses, as by Fig. 2.*

Draw the Line A B, and place one Foot of your Compasses upon the point you would have the Perpendicular erected, as at the point C, and with the other foot describe the Semi-Circle A a b B, then placing one Foot in B, extend the other Foot to b, in



in the Semi-Circle; and keeping that Foot in *b*, extend the other Foot to *D*, and make there a small Arch: Then remove one Foot of your Compasses to *A*, and extend the other Foot to *a* in the Semi-Circle, and keeping that Foot in *a*, extend the other to *D*, and make there another small Arch, to cut the first small Arch; and laying a straight Ruler to the point where these two small Arches cut each other, and upon the point *C*, draw by the side of the Ruler the Line *C D*, which shall be Perpendicular to the Line *A B*.

*To erect a Perpendicular upon the end of a Line, as by Fig. 3.*

On the point *B*, at one end of the Line *A B*, place one Foot of your Compasses in the point *B*, and extend the other on the Line towards *A*, as to *b*, and with it describe the Arch *b a C*; then placing one Foot in *b*, extend the other to *a* in the Arch, and make there a mark; Divide with your Compasses the Arch *b a* into two equal parts, and keeping the Feet of your Compasses at that distance, measure in the Arch from *a* to *C*, then draw a straight Line from the point *C* to the end of the Line *B*, and that straight Line shall be Perpendicular to the end of the Line *A B*.

*To draw a Line Parallel to another Line, as by Fig. 4.*

*Example.* If you would draw a Line Parallel to the Line *AB*, open your Compasses to the distance you intend the Lines shall stand off each other, and placing one Foot successively near each end, describe with the other Foot the small Arches *CD*; lay a straight Ruler to the top of these Arches, and draw a Line by the side of it, and that Line shall be Parallel to the Line *A B*.

*Definitions.*

## Definitions.

**A** *Dyal Plane* is that Flat whereon a *Dyal* is intended to be projected.

Of *Dyal Planes* some be *Direct*, other *Decliners*, others *Oblique*.

Of *Direct Planes* there are five sorts :

1. The *Horizontal* whose Plane lies flat, and is parallel to the *Horizon*, beholding the *Zenith*.
2. The *South Erect*, whose Plane stands upright, and directly beholds the *South*.
3. The *North Erect*, whose Plane stands upright, and directly beholds the *North*.
4. The *East Erect*, whose Plane stands upright, and directly beholds the *East*.
5. The *West Erect*, whose Plane stands upright, and directly beholds the *West*.

Of *Decliners* there are infinite : and yet may be reduced into these two *Kinds* :

1. The *South Erect* Plane, declining more or less towards the *East* or *West*.
2. The *North Erect* Plane, declining more or less towards the *East* or *West*.

Of *Oblique Planes* some are *Direct*, others *Declining* ; and are of four sorts :

1. *Direct Inclining* Planes, which lean towards you, and lie directly in the *East*, *West*, *North*, or *South* quarters of Heaven.
2. *Direct Reclining* Planes, which lean from you, and lie directly in the *East*, *West*, *North*, or *South* quarters of Heaven.
3. *Inclining Declining* Planes, which lean towards you, but lie not directly in the *East*, *West*, *North*, or  
South

*South* quarters of Heaven: But decline more or less from the *North* or *South*, towards the *East* or *West*.

4. *Reclining Declining* Planes, which lean from you, but lie not directly in the *East*, *West*, *North*, or *South* quarters of Heaven: But Decline more or less from the *North* or *South*, towards the *East* or *West*.

If the Scituation of the *Plane* be not given, you must seek it: For, there are several wayes how to know these several kinds of *Planes* used among Artists; But the readiest and easiest is by an Instrument called a *Declinator*, fitted to the variation of your Place: And if it be truly made, you may as safely rely upon it as any other.

### OPERATION I.

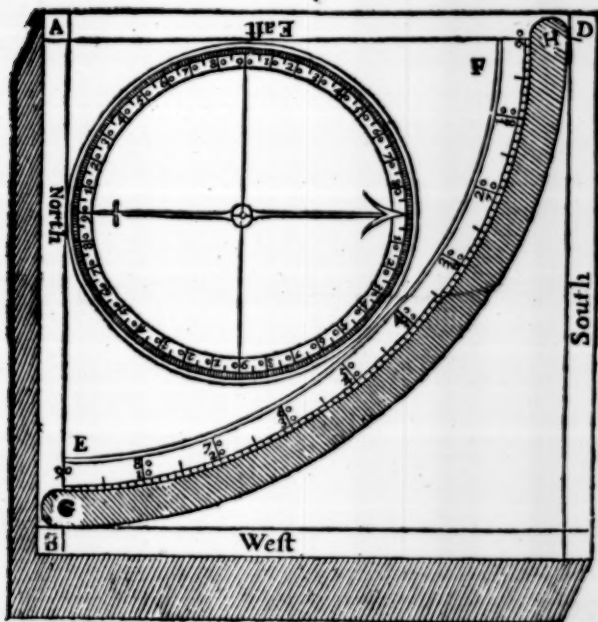
#### *The Description of the Clinatory.*

THE Clinatory is made of a square Board, as ABCD, of a good thickness, and the larger the better; between two of the side is described on the Center A a *Quadrant* as EF divided into 90 equal parts or degrees, which are figured with 10, 20, 30, to 90; and then back again with the Complements of the same numbers to 90: between the Limb and the two Semi-diameters is made a round Box, into which a Magnetical Needle is fitted; and a Card of the Nautical Compass, divided into four Nineties, beginning their numbers at the East, West, North, and South points of the Compass, from which points the opposite sides of the Clinatory receives their Names of East, West, North and South.

But, *Note*, that the North point of the Card must be placed so many degrees towards the East or West sides of the Clinatory as the Needle varies from the true North

North point of the world, in the place where you make your Dyal; which your Workman that makes your Clinatory will know how to fit.

Upon the Center A, whereon the *Quadrant* was described, is fastened a Plumb-line, having a Plumbet of Lead or Brasse fastned to the end of it, which Plumb-line is of such length that the Plumbet may fall just into the Groove GH, below the *Quadrant*, which is for that purpose made of such a depth that the Plumbet may ride freely within it, without stopping at the sides of it. See the Figure annexed.



With this Clinatory you may examine the scituation of Planes. As if your Plane be Horizontal, it is direct: and then for the true scituating your Dyal you have only the true North and South Line to find: which is done only by setting the Clinatory flat down upon the Plane, and turning it towards the right or left hand, till you can bring the North point of the Needle to hang just over the Flower-de-luce, for then if you draw a Line by either of the sides parallel to the Needle, that Line shall be a North and South Line.

If Your Plane either Recline or Incline, Apply one of the sides of your Clinatory parallel to one of the Semi-diameters of the *Quadrant* to the Plane, in such sort that the Plumb-line hanging at liberty, may fall upon the Circumference of the *Quadrant*, for then the number of degrees of the *Quadrant* comprehended between the side of the *Quadrant* parallel to the Plane, and the Plumb-line shall be the number of degrees for Reclination, if the Center of the *Quadrant* points upwards; or Inclination, if the Center points downwards.

If your Reclining or Inclining Plane Decline, Draw upon it a Line parallel to the Horizon, which you may do by applying the back-side of the Clinatory, and raising or depressing the Center of the *Quadrant*, till the Plumb-line hang just upon one of the Semi-diameters, for then you may by the upper side of the Clinatory draw an Horizontal Line if the Plane Incline, or by the under side if it Recline. If it neither Incline or Recline, you may draw a Horizontal Line both by the upper and under sides of the Clinatory. Having drawn the Horizontal Line, apply the North side of the Clinatory to it, and if the North end of the Needle points directly towards the Plane, it is then a South Plane. If the North point of the Needle points directly from the Plane,

it is a North Plane : but if it points towards the East, it is an East Plane : if towards the West, a West Plane. If it do not point directly either East, West, North, or South, then so many degrees as the Needle declines from any of these four points to any of the other of these four points, so many degrees is the Declination of the Plane.

You may find a Meridian Line another way ; thus, If the Sun shine just at Noon, hold up a Plumb-line so as the shadow of it may fall upon your Plane, and that shadow shall be a *Meridian Line*.

## OPERAT. II.

*To describe a Dial upon a Horizontal Plane:*

First draw a North and South Line (which is called a *Meridian Line*) through the middle of the Plane: Thus, Set your *Declinatory* flat upon the Plane, and turn it to and fro till the Needle hang precisely over the *Meridian Line* of the *Declinatory*; then by the side of the *Declinatory* parallel to its *Meridian Line*, draw a straight Line on the Plane, and if that straight Line be in the middle of the Plane, it shall be the *Meridian Line*, without more ado: But if it be not in the middle of the Plane, you must draw a Line parallel to it through the middle of the Plane for the *Meridian Line*, or twelve a Clock line: And it shall be the *Meridian Line*, and also be the *Substilar Line*; then draw another straight Line through the middle of this Line, to cut it at right Angles for the VI. a Clock Lines; and where these two Lines cut one another make your Centre, whereon describe a Circle on your *Plane* as large as you can, which by the *Meridian Line*, and the Line drawn at right An-



gles with it will be devided into four *Quadrants*; one of the *Quadrants* devide into 90 degrees thus, Keeping your Compasses at the same width they were at when you described the *Quadrant*, place one Foot in the twelve a Clock Line, and extend the other in the *Quadrant*, and make in the *Quadrant* a mark with it; so shall you have the sixtieth degree marked out: then place one Foot of your Compasses in the six a Clock Line, and extend the other in the *Quadrant*, and make in the *Quadrant* another mark with it; so shall that *Quadrant* be divided into three equal parts; each of these three equal parts contains 30 degrees: Then with your Compasses devide one of these three equal parts into three parts, and transfer that distance to the other two third parts of the *Quadrant*, so shall the whole *Quadrant* be devided into nine equal parts. Then devide one of these nine equal parts into two equal parts, and transfer that distance to the other eight equal parts, so shall the *Quadrant* be devided into eighteen equal parts. Then devide one of these eighteen equal parts into five equal parts, and transfer that distance to the other seventeen equal parts, so shall the whole *Quadrant* be devided into 90 equal parts. Each of these 90 equal parts are called *Degrees*.

*Note*, That you may in small *Quadrants* devide truer and with less trouble with Steel Dividers, (which open or close with a Screw for that purpose,) than you can with Compasses.

In this *Quadrant* (thus devided) count from the *Substilar* or *Meridian Line* the Elevation of the *Pole*, that is, the number of Degrees that the *Pole* of the World is elevated above the *Horizon* of your Place, and draw a Line from the Center through that number of Degrees for the *Stilar Line*. Then on the *Substilar Line* choosẽ



choose a point (where you please) and through that point draw a Line at right Angles to the *Substilar Line* as long as you can, for the *Line of Contingence*, and from that point in the *Substilar Line* measure the nearest distance any part of the *Stilar Line* hath to that point; and keeping one Foot of your Compasses still in that point, set off that distance in the *Substilar Line*, and at that distance describe against the *Line of Contingence* a Semi-Circle, which divide from either side the *Meridian* or *Substilar Line* into six equal parts thus; Draw a Line through the Center of this Semi-Circle parallel to the *Line of Contingence*, which shall be the *Diametral Line*, and shall divide this Semi Circle-into two *Quadrants*; one on one side the *Substilar Line*, and the other *Quadrant* on the other side the *Substilar Line*: Then keeping your Compasses at the same distance they were at when you described the Semi-Circle, place one Foot first on one side the *Diametral Line* at the Intersection of it and the Semi-Circle, and then on the other side, at the Intersection of it and the Semi-Circle, and extend the other in the Semi-Circle, and make marks in the Semi-Circle on either side the *Substilar Line*: Then place one Foot of your Compasses at the Intersection of the Semi-Circle and the *Substilar Line*, and turn the other Foot about on either side the Semi-Circle and make marks in the Semi-Circle, so shall the Semi-Circle be divided into six equal parts: Divide one of these equal parts into two equal parts, and transfer that distance to the other five equal parts, so shall the whole Semi-Circle be divided into twelve equal parts. These twelve Divisions are to describe the twelve Hours of the Day, between six a Clock in the Morning, and six a Clock at Night.

If you will have half Hours you may divide each of these

these twelve into two equal parts, as before: If you will have Quarters you may divide each of these twenty four into two equal parts more, as before.

For thus proportioning the Devisions in the Semi-Circle, you may proportion the Devisions and Sub-devisions of Hours upon the *Dyal Plane*; for a straight Ruler laid upon each of these Devisions, and on the Center of this Semi-Circle, shall shew on the *Line of Contingence* the several Distances of all the Hours and parts of Hours on the *Dyal Plane*: And straight Lines drawn from the Center of the *Dyal Plane*, through the several Devisions on the *Line of Contingence* shall be the several Hour Lines and parts on the *Dyal Plane*.

But an *Horizontal Dyal* in our Latitude will admit of four Hours more, *viz.* V, IV, in the Morning, and VII, VIII, in the Evening. Therefore in the Circle described on the Center of the *Dyal Plane* transfer the distance between VI and V, and VI and IV, on the other side the fix a Clock Line; And transfer the Distances between VI and VII, and VI and VIII on the other side the opposite fix a Clock Hour Line, and from the Center of the *Dyal Plane* draw Lines through those transferred Distances for the Hour Lines before and after VI.

Then mark your Hour Lines with their respective numbers. The *Substilar Line* in this Dyal (as aforesaid) is XII, from thence towards the right hand mark every successive Hour Line with I, II, III, &c. and from XII towards the left hand with XI, X, IX, &c.

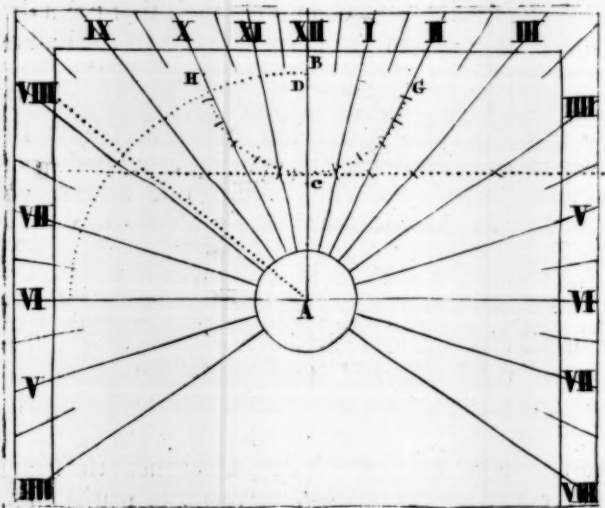
The *Stile* must be erected perpendicularly over the *Substilar Line*, so as to make an Angle with the *Dyal Plane* equal to the *Elevation* of the *Pole* of your Place.

Example.

## Example.

You would draw a Dyal upon a *Horizontal Plane* here at *London*; First draw the *Meridian* (or North and South Line) as XII B, and cross it in the middle with another Line at right Angles, as VI, VI, which is an East and West Line; where these two Lines cut each other as at A, make the Center, whereon describe the Semi-Circle B, VI. VI; but one of the *Quadrants*, viz. the *Quadrant* from XII to VI, towards the right hand you must divide into 90 equal parts (as you were taught in *Fol. 12.*) and at  $51\frac{1}{2}$  degrees (which is *Londons* Latitude) make a mark, and laying a straight Ruler to the Center of the *Plane*, and to this mark draw a Line by the side of it for the *Stilar Line*. Then on the *Substilar Line* chuse a point as at C, and through that point draw a Line as long as you can perpendicular to the East and West Line VI, VI, as EF, (which is called the *Contingent Line*,) where this *Contingent Line* cuts the *Substilar Line* place one Foot of your Compasses, and from thence measure the shortest distance between the point C and the *Stilar Line*. And keeping one Foot of your Compasses still in the point C, set off the shortest distance between the point C and the *Stilar Line* on the *Substilar Line*, as at D; which point D shall be a Center, whereon with your Compasses at the same width you must describe a Semi-Circle to represent a Semi-Circle of the *Equinoctial*. This Semi-Circle divide into six equal parts (as you were taught *Fol. 13.*) to each of which equal parts, and to the Center of the *Equinoctial* Semi-Circle lay a straight Ruler, and where the straight Ruler cuts the *Line of Contingence* make marks in the *Line of Contingence*. Then lay the straight Ruler to the  
Semi-

Circle of the *Dyal Plane*, and to each of the marks in the *Line of Contingence*, and by the side of it draw twelve straight Lines for the twelve Fore and Afternoon Hour Lines, viz. from VI in the Morning to VI in the Evening. Then in the *Quadrant VI B*, measure the distance between the VI a Clock Hour Line, and the V a Clock Hour Line, and transfer the same distances from the VI a Clock Line to VII, and V on both sides the VI a Clock Hour Lines, and through those distances draw from the Center of the Plane the VII and V a Clock Hour Lines, and measure the distance between the VI a Clock Hour Line and the IV a Clock Hour Line, and transfer the same distance from the VI a Clock Line to VIII and IV, and through those distances draw from the Center of the Plane the VIII a Clock and IV a Clock Hour Lines.



If you will have the half Hours and quarter Hours, or any other devision of hours, you must devide each fix devisions of the *Equinoctial* into so many parts as you intend, and by a straight Ruler laid to the Center of the *Equinoctial*, and those devisions in the *Equinoctial* Circle make marks in the *Line of Contingence*, as you did before for the whole Hour Lines; and Lines drawn from the Center of the Plane through those marks shall be the sub-devisions of the Hours: But you must remember to make all sub-devisions short Lines, and near the verge of the *Dyal Plane*, that you may the easier distinguish between the whole Hours and the parts of Hours; as you may see in the Figure.

Having drawn the Hour Lines, set the number of each Hour Line under it, as you see in the Figure.

Last of all fit a Triangular Iron, whose angular point being laid to the Center of the *Dyal Plane*, one side must agree with the *Substilar Line*, and its other side with the *Stilar Line*; so is the *Stile* made. And this *Stile* you must erect perpendicularly over the *Substilar Line* on the *Dyal Plane*, and there fix it. Then is your *Dyal* finished.

### OPERAT. III.

*To describe an Erect Direct South Dyal.*

**Y**OU may know an *Erect Direct South Plane* by applying the North side of the *Declinatory* to it; For then if the North end of the Needle hang directly over the North point of the Card in the bottom of the Box, it is a *South Plane*; but if it hang not directly over the North point of the Card, it is not a *Direct South Plane*, but *Declines* either East or West, and that

contrary to the pointing of the Needle Easterly or Westerly from the North point of the Card: for if the North point of the Needle points Easterly, the *Plane Declines* from the South towards the West: if it point Westerly, the *Plane Declines* from the South towards the East.

You may know if the *Plane* be truly *Erect* or upright, by applying one of the sides A B or A D to it; for then by holding the Center A upwards, so as the Plumb-line play free in the Grove, if the Line falls upon 0, or 90, the *Plane* is upright; but if it hang upon any of the intermediate Degrees, it is not upright, but *Inclines* or *Reclines*.

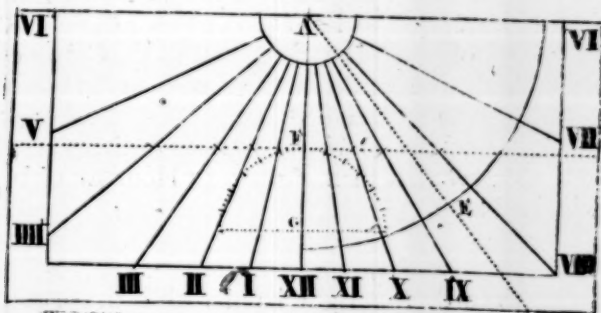
If you find it *Incline*, apply the side A B to it, and see what number of Degrees the Plumb-line falls on, for that number of Degrees counted from the side A B, is the number of Degrees of *Inclination*.

If you find the *Plane Reclines*, apply the side A D to it, and see what number of Degrees the Plumb-line falls on, for that number of Degrees counted from the side A D is the number of Degrees of *Reclination*.

These Rules being well understood, may serve you to find the situation of all other sorts of Planes.

But for the making a *Dyal* on this *Plane*, you must first draw a *Meridian Line* through the middle of the *Plane*, by applying a Plumb-line to the middle of it, till the Plumbet hang quietly before it: for then if the Plumb-line be black't (for a white Ground, or chalked for a dark Ground) and strained as Carpenters do their Lines, you may with one stroak of the string on the *Plane* describe the *Meridian Line*, as A XII: This *Meridian* is also the *Subsilar Line*.

Then



Then on the top of this *Meridian Line*, as at *A*, draw another Line athwart it to cut it at right Angles, as *VI*, *VI*, for an East and West Line. At the meeting of these two Lines on the top, make your Center, whereon describe a Semi-Circle on your *Plane*, as large as you can, which by the *Meridian Line* and the East and West Line will be divided into two *Quadrants*. One of these *Quadrants* divide into 90 Degrees (as you were taught *Fol. 12.*) and from the *Substilar Line* count the Complement of the *Poles Elevation*, which (here at *London* where the *Pole* is elevated  $51\frac{1}{2}$  Degrees, its Complement to 90) is  $38\frac{1}{2}$  Degrees, and make there a mark, as at *E*. Then on the *Substilar Line* chuse a point (where you please) as at *F*, for the *Line of Contingence* to pass through: which *Line of Contingence* draw as long as you can, so as it may cut the *Substilar Line* at right Angles, and from the point *F* in the *Substilar Line* measure the shortest distance between it and the *Stilar Line*, and keeping one Foot of your Compasses still in the point *F*, transfer that distance into the *Substilar Line*, as at *G*; then on the point *G* describe a Semi-Circle of the *Equinoctial* against the *Line of Contingence*, which Semi-Circle divide into



twelve equal parts, (as you were taught by the *Example* in the *Horizontal Dyal*, Fol. 13.) and by a straight Ruler laid to each of these Divisions, and to the Center of the Semi-Circle make marks in the *Line of Contingence* by the side of the Ruler: For straight Lines drawn from the Center of the *Dyal Plane* through these marks in the *Contingent Line* shall be the 12 Hour Lines before and after Noon.

Then mark your Hour Lines with their respective Numbers: The *Substilar* or *Meridian Line* is XII, from thence towards the right hand with I, II, III, &c. and from thence towards the left hand with XI, X, IX, &c.

The *Stile* must be erected perpendicularly over the *Substilar Line*, so as to make an Angle with the *Dyal Plane* equal to the Complement of the *Poles Elevation*, viz.  $38\frac{1}{2}$  Degrees.

#### OPERAT. IV.

*To make an Erect Direct North Dyal.*

THE *Erect Direct North Dyal*, *Stile* and all, is made by the same Rules, changing upwards for downwards, and the left side for the right, the *Erect Direct South Dyal* is made: for if the *Erect Direct South Dyal* be drawn on any transparent Plane, as on Glass, Horn, or an oyled Paper, and the *Horizontal Line* VI, VI, turned downwards, and the *Line VII* mark't with V, the *Line VIII* with IIII, the *Line V* with VII, and the *Line IIII* with VIII, then have you of it a *North Erect Direct Dyal*.

All the other Hour Lines in this *Dyal* are useles, because the Sun in our *Latitude* shines on a North Face the longest Day only before VI in the Morning, and after VI at Night.

OPERAT.

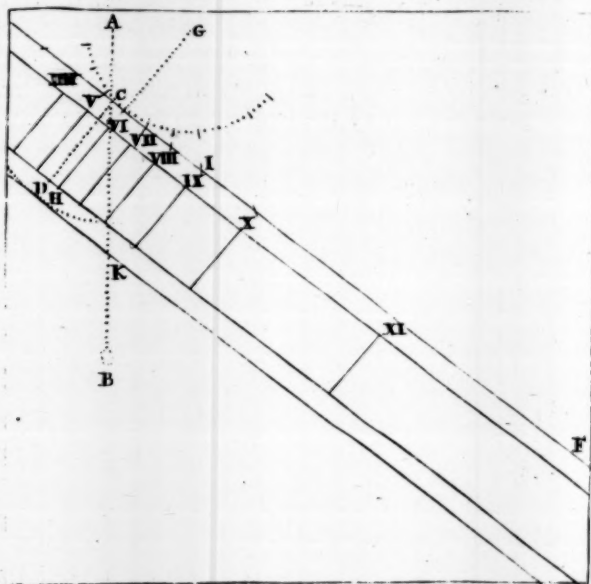


## OPERAT. V.

To describe an Erect direct East Dyal.

**H**Ang a Plumb-line a little above the place on the Wall where you intend to make your Dyal, and wait till it hang quietly before the Wall: Then if the Line be rubbed with Chalk (like a Carpenters Line) you may by holding the Plumbet end close to the Wall, and straining it pretty stiff, strike with it a straight Line, as Carpenters do: This Line shall be a perpendicular, as A B. Then chuse a convenient point in this Perpendicular, as at C, for a Center, whereon describe an occult Arch, as DE; This Arch must contain the number of Degrees of the *Elevation* of the *Equinoctial*, counted between D and E, which in our *Latitude* is  $38^{\frac{1}{2}}$ , or (which is all one) the Complement of the *Poles Elevation*. Therefore in a *Quadrant* of the same *Radius* with the occult Arch measure  $38^{\frac{1}{2}}$  Degrees, and set them off in the Plane from E to D: Then from D to the Center C in the Perpendicular draw the prick't Line DC; this prick't Line shall represent the *Axis of the World*. Then cross this Line at right Angles with the Line CF, and draw it from C to F, so long as possibly you can: This Line shall be the *Contingent Line*. Then chuse a point in this *Contingent Line*, as at VI, draw a Line through that point at right Angles for the *Substilar Line*, as G VI H for the *Substilar Line*; then open your Compasses to a convenient width, (as to VIG) and pitching one Foot in the point G, with the other Foot describe a Semi-Circle of the *Equinoctial* against the *Line of Contingence*, which Semi-Circle divide from VI both wayes into six equal parts, as you were taught by the *Example* in the  
Hori-

*zontal Dial*: and laying a straight Ruler on the Center of this Semi-Circle of the *Equinoctial*, and to each of those equal parts mark on the *Contingent Line* where the Ruler cuts it, for those marks shall be the several points from whence Lines drawn parallel to the Line CD shall be the respective Hour Lines.



The reason why the *Contingent Line* is drawn from VI. to F, so much longer than from VI to C is; because the Hour Lines from VI towards XII are more in number towards Noon, than they are from VI backward towards III: for this *Dial* will only shew the Hours from

from a little before IV in the Morning to almost Noon: For just at Noon the Shaddow goes off the Plane; as you may see if you apply a straight Ruler to the Center of the *Equinoctial* Semi-Circle G, and lay it to the point 12 in the Semi-Circle; for the straight Ruler will then never cut the *Line of Contingence*, because the *Line of Contingence* is parallel to the Line GXII on the *Equinoctial* Circle, and Lines parallel, though continued to never so great a length never meet.

To these *Hour Lines*, set Figures as may be seen in the Scheme.

The *Stile* IK of this Dyal as well as of all others must stand parallel to the *Axis of the World*; and also parallel to the Face of the *Plane*, and parallel to all the *Hour Lines*, and stand directly over the *Substilar* or VI a Clock *Hour-Line*, and that so high as is the distance of the Center of the *Equinoctial* Semi-Circle from the *Contingent Line*.

## OPERAT. VI.

To describe a Dyal on an Erect Direct West Plane.

**A**N Erect Direct West Dyal, is the same in all respects with an Erect Direct East Dyal: Only as the East Dyal shews the Forenoon Hours, so the West shews the Afternoon Hours.

Thus if you should draw the East Dyal on any transparent Plane, as on Glas, Horn, or oyled Paper, on the one side will appear an East Dyal, on the other side a West: Only the numbers to the *Hour Lines* (as was said before in the North Dyal) must be changed; for that which in the East Dyal is XI, in the West must be I; that which in the East Dyal is X, in the West must

must be II; that which in the *East Dial* is IX, in the *West* must be III, &c. The *Stile* is the same.

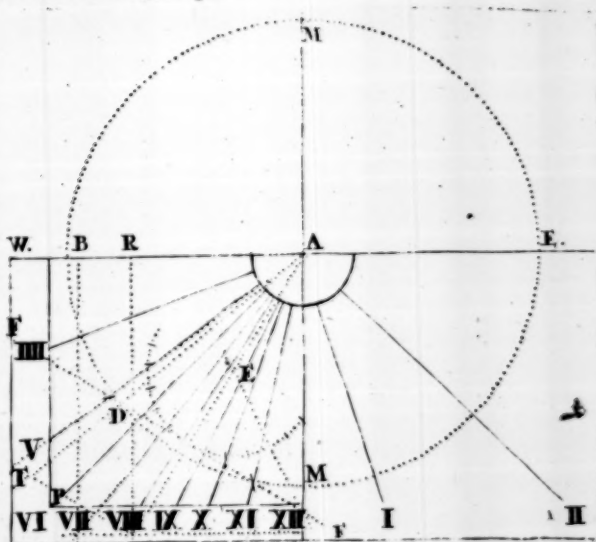
## O P E R A T. VII.

*To describe a Dial on an Erect North, or Erect South Plane Declining Eastwards or Westwards.*

**T**Hese four Dyals, viz. the *Erect North Declining Eastwards*, the *Erect North Declining Westwards*, the *Erect South Declining Eastwards*, and the *Erect South Declining Westwards*, are all projected by the same Rules; and therefore are in effect but one *Dial* differently placed, as you shall see hereafter.

First draw on your *Plane* a straight Line to represent the *Horizon* of your place, and mark one end of it W for *West*, and the other end E for *East*. Chuse a point in this *Horizontal* Line for a Center, as at A, whereon you may describe a Circle to comprehend all these four Dyals: Draw a Line as M A M perpendicular to the *Horizontal* Line W E, through the Center A for a *Meridian* Line, and on that Center describe a Circle, which by the two Lines W A E, and M A M will be divided into four *Quadrants*, which will comprehend the four Dyals aforesaid: for if it be a *North declining West* you are to draw, the upper *Quadrant* to the left hand serves your purpose: If a *South Declining West*, the same Lines continued through the Center A into the lower *Quadrant* to the right Hand serves your turn; if a *North Declining East*, the upper *Quadrant* to the right Hand serves your turn; or if a *South Declining East*, the same Lines continued through the Center A into the lower *Quadrant* to the left hand serves your turn; and you must draw the *Declination*, *Complement of the Poles Altitude*, *Substile*, *Stile* and

and *Hour Lines* in it; but the *Hour Lines* must be differently marked as you shall see hereafter. I shall onely give you an Example of one of these *Dyals*; viz. A *South Declining East*.



We will suppose you are to draw a *Dyal* that declines from the *South* 50 Degrees towards the *East*; here being but one *Dyal*, you need describe but one *Quadrant* of a Circle. Set off in the lower *Quadrant* W A M 50 degrees from the *Meridian Line* M towards W, and from the Center A draw a straight Line through that mark in the *Quadrant* as D A, which may be called the *Line of Declination*; then set off from the *Meridian Line* the *Complement* of the *Poles Elevation*, which in our Latitude is 38 $\frac{1}{2}$  degrees, and there draw another Line from the Center as A P, which we will  
D call

call the *Polar Line*. Then take in the *Horizontal Line* a convenient portion of the *Quadrant*, as A B, and from the point B draw a Line parallel to the *Meridian Line* A M, and continue that Line till it intersect the *Polar Line*, as at P, from which Point P draw a Line parallel to W A, as P C: Then measure the distance of A B in the *Horizontal Line*, and set off that distance in the Line of *Declination*, as from A to D, and from that point of distance draw a Line parallel to the *Meridian* A M through the *Horizontal Line* at R, and through the Point D, and continue it through the Line P C, as at S; then laying a straight Ruler to the Center A, and the Intersection of the Line P C, at S draw the Line A S for the *Substile*: Then upon the Point S erect a Line perpendicularly as S T; Then measure the distance between R and D, and set that distance off from S to T, and from the Center to the point T draw the Line A T for the *Stile* or *Gnomon*; and the Triangle S A T made of Iron or Brasse and erected perpendicularly over the *Substile* S A shall by its upper side T A cast a shadow upon the Hour of the day. But you will say the *Hour Lines* must be drawn first: It is true; Therefore to draw them you must chuse a point in the *Substile Line* where you think good, and through it draw the Line F F as long as you can for the the *Line of Contingence*: then with your Compasses take the shortest distance between this point and the *Stile*, and transfer that distance below the *Line of Contingence* on the *Substile* as at Æ, and with your Compasses at that distance describe on the Center Æ a Circle to represent the *Equinoctial*; Then (as you were taught in the Example of the *Horizontal Dial*) divide the Semi-Circle of the *Equinoctial* into twelve equal parts, beginning at the point in the *Equinoctial Circle*, where a straight

straight Line drawn from the Center of it to the Intersection of the Line of *Contingence* with the *Meridian* Line cuts the *Equinoctial* Line, as here at the Point G; Then lay a straight Ruler to the Center of the *Equinoctial* Circle, and to every one of the Devisions in the Semi-Circle, and mark where the straight Ruler cuts the *Contingent* Line; for straight Lines drawn from the Center A of the Dyal to those several marks on the *Contingent* Line shall be the *Hour* Lines; and must be numbred from the Noon Line or *Meridian* A M backwards, as XII, XI, X, IX. &c. towards the left hand. So is your *Dyal* finished.

This *Dyal* drawn on any transparent matter as Horn, Glas, or an oyled Paper, shall on the other side the transparent matter become a *South Declining West*, (*Stile* and all) but then the I a Clock Hour Line must be marked II, the XII XII, the XI a Clock Hour Line I, X, II, IX, III, &c.

If you project it anew, you must describe the *Quadrant* M W on the other side the *Meridian* Line, on the Center A from M to E, and then count, (as before) the *Declination*, *Altitude* of the *Pole*, *Substile*, and *Stile* in the *Quadrant*, beginning at M towards E, and work in all respects as with the *South Declining East*; only number this *South Declining West* as in the foregoing Paragraph.

If you project a *North Declining East*, you must describe the *Quadrant* above the *Horizontal* Line from M upwards, towards E on your right hand, and count (as before) the *Declination*, *Altitude*, *Complement* of the *Pole*, *Substile*, and *Stile* from the *Meridian* Line, and work as with the *South Declining East*: It must be numbred from the *Meridian* Line M towards the right hand with XI, X, IX, VIII, &c.



If this *Dyal* were drawn on transparent matter, the other side would shew a *North Declining West*: But if you will project it anew, you must describe the *Quadrant* above the *Horizontal Line*, from M upwards towards W, and count from the *Meridian Line* A M the *Declination*, *Complement*, *Altitude of the Pole*, *Substile* and *Stile*, and work with them (in all respects) as with the *South Declining East*; but then the XI a Clock Hour Line must be marked I, the X, II; the IX, III, &c.

## OPERAT. VIII.

*To draw a Dyal on an East or West Plane Reclining,  
or Inclining.*

**D**raw a straight Line parallel to the *Horizon*, to represent a *Meridian*, or XII a Clock Line, and mark one end N, the other S; Chuse a point in this Line, as at A for a Center: then if your Plane be an *East* or a *West Incliner*, let fall a Perpendicular upon this Center, (that is, the Perpendicular must stand above the *Meridian Line* NS.) as AE, and upon the Center A describe a Semi-Circle above the *Meridian Line* N S;) But if your Plane be an *East Incliner*, or a *West Recliner*, let fall a Perpendicular from the Center A under the *Meridian Line*, and upon the Center A describe a Semi-Circle under the *Meridian Line*. If your Plane be a *West Incliner*, work (as shall be taught) in the *Quadrant* on the left hand above the *Meridian Line*. If an *East Recliner*, in the *Quadrant* on the right hand above the *Meridian Line*. If it be a *West Recliner*, work in the *Quadrant* on the left hand under the *Meridian*. If an *East Incliner*, in the *Quadrant* under the *Meridian Line* the right hand.

*For*

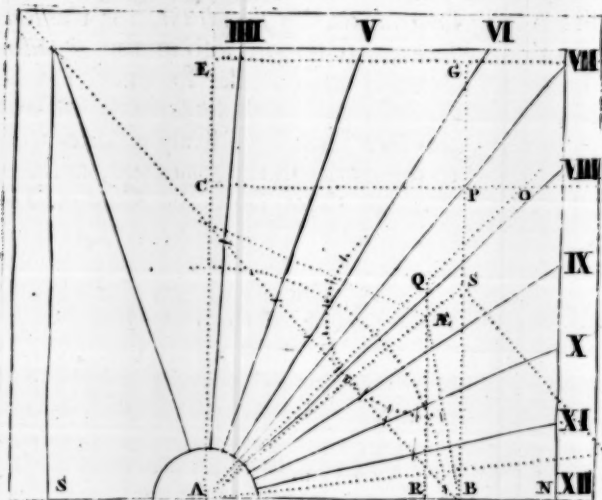


For Example, An East Dial Reclining 45 Degrees.

You would draw a Dial on an East Plane Reclining 45 Degrees: Therefore in the Quadrant on the right hand above the Meridian Line, set off from the Perpendicular AE 45 Degrees on the Quadrant, for the Reclination of the Plane; and set off also in the Quadrant 38½ Degrees from the Perpendicular for the Complement of the Poles Elevation, and at these settings off make marks in the Quadrant: Then lay a straight Ruler to the Center A, and to the marks in the Quadrant, and draw straight Lines through them from the Center. Then chuse in the Meridian Line NS a convenient point, as at B, and through that point draw a Line parallel to the Perpendicular AE, which will intersect the Line drawn for the Complement of the Poles Elevation AP in P; from which point P, draw a Line parallel to the Meridian Line NS, to cut the Perpendicular AE in C, and also the Line of Obliquity AO in O. Then measure the length AO, and set off that length in the Perpendicular ACE from A to E, and draw the Line EG parallel to the Meridian Line NS, which will cut the Line BP prolonged in G. Measure also the length of CO, and set that length off from A to Q on the Line of Obliquity AO, and draw the Line QR parallel to the Perpendicular ACE. Then measure the distance of AR, and upon the Line GPB set it off from G to S; and laying a straight Ruler to the point S and the Center A, draw by the side of it the Line AS; for the Substile Line. Then measure the length of QR, and from S raise a Perpendicular, and in that Perpendicular set that length off from S to T; and laying a straight Ruler to the Center A and the point T, draw the Line

AT

AT for the *Stilar Line*, which *Stilar Line* being perpendicularly erected over the *Substilar Line* AS, will stand parallel to the *Axis of the World*, and cast its shadow on the Hour of the Day.



To draw the Hour Lines on this Plane, you must (as you have several times before been directed) chuse a point in the *Substilar Line*, and through that point draw at right Angles with the *Substilar Line* the *Line of Contingence* so long as you can: Then measure the shortest distance between that Point and the *Stilar Line*, and transfer that distance below the *Line of Contingence* in the *Substilar Line*, as at AE, and with your Compasses

passes at that distance describe against the *Line of Contingence* the *Equinoctial Circle*; Then divide the Semi-Circle of the *Equinoctial* next the *Line of Contingence* into twelve equal parts, (as you have formerly been taught) beginning at the Point in the *Equinoctial Circle*, where a straight Line drawn from the Center of it to the Intersection of the *Line of Contingence* with the *Meridian* Line N S cuts the *Equinoctial Circle*, as here at the point D: Then lay a straight Ruler to the Center of the *Equinoctial Circle*, and to every one of the Divisions in the *Equinoctial* Semi-Circle, and mark where the straight Ruler cuts the *Contingent Line*: for straight Lines drawn from the Center A of the *Dyal* through these several marks in the *Contingent Line* shall be the Hour Lines, and must be numbred from the *Meridian* or Noon-Line N S which is the XII a Clock Line upwards, with XI, X, IX, VIII, &c. The Center of this *Dyal* must stand downward.

If this *Dyal* were turned with its Center upwards, it would shew a *West Inclining* 45 degrees, only the numbers to the Hour Lines must be changed; for to XI you must set I, to X, II; to IX, III, &c. and the *Substile* over which the *Stile* must stand, must be placed in the Semi-Circle (at first described) as much to the right hand the Perpendicular A E, as it doth on the left hand.

If this *Dyal* were drawn on Glasse, Horn, or an oyled Paper, and you turn the *Meridian* Line N S upwards, the backside shall be an *East Inclining* 45 degrees, and the Hour Lines must be numbred as they are on the *East Reclining*: But the *Substile* over which the *Stile* must stand, must be placed, in the Semi-Circle (at first described) as much to the left hand the Perpendicular A E, as it is on the oyled Paper to the right hand.

If

If you turn the *Meridian Line* N S downwards, the backside shall be a *West Recliner* 45 degrees, and the *Hour Lines* must be numbred from the XII a Clock Line upwards, with I, II, III, &c.

You must note that all the *Hour Lines* of the Day will not be described in this single *Quadrant*, nor does the *Quadrant* at all relate to the *Hour Lines*; but is described onely for setting off the *Complement of the Poles Elevation* and *Reclination* of the *Plane*, that by working (as hath been shewn) you may find the place of the *Substilar Line*, and the Angle the *Stile* makes with it: For having the *Substilar Line*, you know how to draw the *Line of Contingence*, and to describe the *Equinoctial Circle*, by which all the *Hours* are described on the *Plane*.

To draw a Dyal on a Direct South or North Plane  
Inclining or Reclining.

*Direct Reclining* or *Inclining* Dyals are the same with *Erect Direct* Dyals that are made for the *Latitude* of some other Places; the *Latitude* of which Places are either more than the *Latitude* of your Place, if the *Plane Recline*; or less, if the *Plane Incline*: and that in such a proportion as the Arch of *Reclination* or *Inclination* is.

Thus a *Direct South Dyal Reclining* 10 degrees in *London's Latitude*, (*viz.* 51 $\frac{1}{2}$  degrees) is an *Erect Direct South Dyal* made for the *Latitude* of 61 $\frac{1}{2}$  degrees. And a *Direct South Dyal Inclining* 10 in the *Latitude* of 51 $\frac{1}{2}$  is an *Erect Direct South Dyal* in the *Latitude* of 41 $\frac{1}{2}$  degrees: and is to be made according to the Direction given in *Operat. III.*

OPERAT.

## OPERAT. IX.

To draw a Dial on a South or North Inclining Declining, or Reclining Declining Plane.

THESE four sorts of *Dyals* viz. the *South Inclining Declining*, and *South Reclining Declining*, and *North Inclining Declining*, and *South Reclining Declining*, are all projected by the same Rules; and therefore are in effect but one *Dyal* differently placed, as you shall see hereafter.

First draw on your *Plane* a straight Line parallel to the *Horizon*, and mark one end W for *West*, and the other E for *East*. On *South Incliners* and *Recliners*, E on the right hand, and W on the left: on *North Incliners* and *Recliners* E on the left hand and W on the right. Chuse a point in this *Horizontal* Line for a Center, as at A; Through this point A draw a Line Perpendicular to the *Horizon*, and on this point (as on a Center) describe a Semi-Circle, one *Quadrant* above, and another below the *Horizontal* Line. (though for this Example I describe but one.) Then if the *Plane* respect the *South*, set off in the lower *Quadrant* from the Perpendicular the *Declination*, the *Inclination*, or the *Reclination*, and the *Complement* of the *Altitude* of the *Pole*; and through these several settings off in the *Quadrant*, draw straight Lines from the Center A; then take in the *Horizontal* Line towards the Semi-Circle, a convenient distance from the Center A, as B, and through the point B draw a straight Line parallel to the Perpendicular, and prolong it through the *Polar* Line, as B P: Through the point P, draw a Line parallel to the *Horizontal* Line, as P C; this Line will cut the Line of *Obliquity* in the point O: Then measure the distance of A O, and set off

E

off



that distance in the *Horizontal* Intersection from F to M, and through the point M draw the Line A M for the *Meridian* Line. Then add the distance of A L to A K, thus: measure the distance of A L, and place one Foot of your Compasses in the point K in the Perpendicular Line, and extend the other to X, and measuring the distance of A X, set it off in the Line of *Obliquity* from A to Q; and from the point Q draw the Line Q R parallel to the Perpendicular, and cutting the *Horizontal* Line in the point R. Then measure the distance of A R, and set off that distance from H in the *Horizontal* Intersection to S on the Line H N, and to the point S draw the Line A S for the *Substile*. Then measure the distance of Q R, and set off that distance perpendicularly from the point S to T; and lastly, from the point A, draw the straight Line A T for the *Stilar* Line, which *Stilar* Line being perpendicularly erected over the *Substilar* Line A S, will stand parallel to the *Axis of the World*, and cast its shadow on the Hour of the Day.

But if the *Plane* be a *Southern Recliner*, or *Northern Incliner*, measure (as before) the distance of L D, and (as before you were directed) to set it off from F in the *Horizontal* Intersection on the right hand the perpendicular Line; So now, set that distance from F to *m* in the *Horizontal* Intersection on the left hand in the Perpendicular Line, and draw the Line A *m* for the *Meridian* Line. Then as before you were directed to add A L to A K: So now, subtract the distance of A L from A K, and the remainder will be L K: Set therefore the distance of I K from A to *q* in the same Line of *Obliquity*, and from the point *q*, draw the Line *q r* parallel to the perpendicular. Measure then the distance of A *r*, and set off that distance in the Line H N, from H to *s* for the *Sub-*



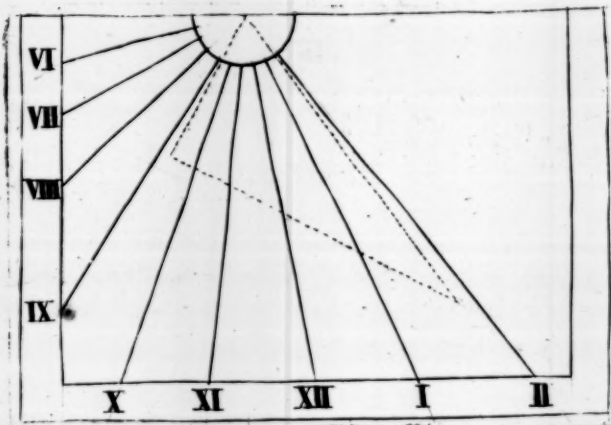
*stilar Line*: Then erect on the point *s* a Perpendicular, and on that Perpendicular set off from *s* to *t* the distance of *q r*: And lastly, from *A* draw the Line *A t* for the *Stilar Line*.

If *K* falls upon *L* the *Plane* is parallel to the *Axis* of the *World*, and the *Dyal* drawn upon it will have no Center: But *s* will fall upon *H*, and *A H* (or *A s*) will be the *Substile*.

I shall give you two Examples of these Rules: One of a *Dyal* with a Center, and the other of a *Dyal* without a Center. And first,

### OPERAT. X.

*How to draw a Dyal with a Center, Declining 20 Degrees, and Inclining 30 Degrees.*



**H**AVING by the foregoing Precepts of the last *Operat.* found the *Substile*, *Stile*, and *Meridian*, you must (as you



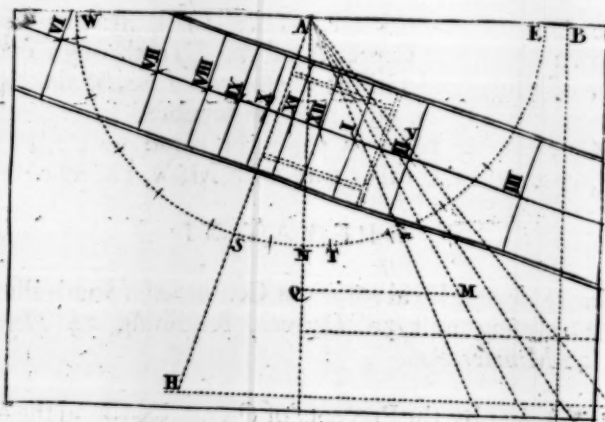
you have often been directed) chuse a point in the *Substilar* Line, through which, at right Angles to the *Substilar* Line draw the *Line of Contingence* as long as you can : Then measure the shortest distance between the point of Intersection and the *Stilar* Line, and transfer that distance on one side the *Line of Contingence* upon the *Substilar* Line, and so describe the *Equinoctial* Semi-Circle against the *Line of Contingence*: Then lay a straight Ruler to the Center of the *Equinoctial* Circle, as at *Æ*, and to the point where the *Line of Contingence* cuts the *Meridian* Line, as at *Z*, and mark where the straight Ruler cuts the *Equinoctial* Circle, and from that mark begin to divide the Semi-Circle into twelve equal parts, and by a straight Ruler laid to those divisions and the Center of the *Equinoctial*, make marks in the *Line of Contingence*. Then shall straight Lines drawn from the Center *A* of the *Dyal* through every one of those marks in the *Contingent* Line be the Hour Lines of the *Dyal*, and must be numbred from the XII a Clock Line towards the right Hand with I, II, III, IV, &c. And the other way with XI, X, IX, &c.

## OPERAT. XI.

*How to draw a Dyal without a Center, on a South Plane;  
Declining East 30 Degrees, Reclining 34 Degrees  
32 Minutes.*

HAVING by the Precepts of *Operat. IX* found the *Substile*, you must find the *Meridian* Line otherwise than you were there taught: For, having drawn the Lines of *Latitude*, *Declination* and *Reclination*, and found the *Substile*, measure the distance of *BP*, and set it off on the Line of *Declination* from *A* to *K*, and draw from the  
Per.

Perpendicular A F the Line K Q parallel to A B : Then measure the length of K Q, and set it off on the *Polar Line* A P, from A to V ; then take the nearest distance between the point V and the Line A B, and set it off on the Line Q K from Q to M ; through which point M, draw a Line from the Center A : Then measure with your Compasses in the Semi-Circle W N E (which in this *Dyal* may represent the *Equinoctial*) the distance of the Arch N m, and set off that distance from the Interfection of the *Substile* with the Semi-Circle at S to T in the Semi-Circle, which point T shall be the point in the *Equinoctial* that you must begin to divide the Hours at, for the finding their distances on the *Line of Contingence*.



Then consider (according to the bigness of your Plane) what height your *Stile* shall stand above the *Substile*, and there make a mark in the *Substile* : For the distance between the Center A and that mark must be

be the height of the *Stile* perpendicularly erected over the *Substile*, as at I. Draw through this point I a Line of *Contingence*, as long as you can to cut the *Substile* at right Angles, and then laying a Ruler to the Center A, and successively to each Devision of the *Equinoctial* make marks in the Line of *Contingence*, and through those marks draw straight Lines parallel to the *Substile*, which shall be the *Hour Lines*; and must be numbred from the left hand towards the right; beginning at the XII a Clock Line with I, II, III, &c. and from the right hand towards the left on the XII a Clock Line with XI, X, IX, &c.

The *Stile* to this Dyal may be either a straight Pin of the length of A I, or else a Square of the same height, erected perpendicularly upon the point I, in the *Substile* Line.

## OPERAT. XII.

*To make a Dyal on the Ceiling of a Room, where the Direct Beams of the Sun never come.*

Find some convenient place in the Transum of a Window to place a small round piece of Looking-Glass, about the bigness of a Groat, or less, so as it may lie exactly Horizontal. The point in the middle of this Glass we will mark A, and for distinction sake call it *Nodus*. Through this *Nodus* you must draw a *Meridian* Line on the Floor, Thus, Hang a Plumb-line in the Window exactly over *Nodus*, and the Shadow that the Plumb-line casts on the Floor just at Noon will be a *Meridian* Line; or you may find a *Meridian* Line otherwise by the Clinatory. Having drawn the *Meridian* Line on the Floor, find a *Meridian* Line on the Ceiling,

ing, thus, Hold a Plumb-line to the Ceeling, over that end of the *Meridian* Line next the Window; If the Plumbet hang not exactly on the *Meridian* Line on the Floor, remove your hand on the Ceeling one way or other, as you see cause, till it do hang quietly just over it, and at the point where the Plumb-line touches the Ceeling make a mark, as at B; that mark B shall be directly over the *Meridian* Line on the Floor: then remove your Plumb-line to the other end of the *Meridian* Line on the Floor, and find a point on the Ceeling directly over it, as you did the former point, as at C, and through these two points B and C on the Ceeling, strain and strike a Line blackt with Smal-Coal or any other Colour (as Carpenters do) and that Line B C on the Ceeling shall be the *Meridian* Line, as well as that on the Floor: Then fasten a string just on the *Nodus*, and remove that string, forwards or backwards, in the *Meridian* Line on the Ceeling, till it have the the same Elevation in the *Quadrant* on the *Clinatory* above the *Horizon* that the *Equinoctial* hath in your Habitation, and through the point where the string touches the *Meridian* Line in the Ceeling shall a line be drawn at right Angles with the *Meridian*, to represent the *Equinoctial* Line.

Thus in our Latitude the Elevation of the Equator being 38 $\frac{1}{2}$  degrees; I remove the string fastned to the *Nodus* forwards or backwards in the *Meridian* Line of the Ceeling, till the Plumb-line of the *Quadrant* on the *Clinatory*, when one of the sides are applied to the string, falls upon 38 $\frac{1}{2}$  degrees: and then I find it touch the *Meridian* Line at D in the Ceeling: therefore at D I make a mark, and through this mark strike the line D E (as before I did in the *Meridian* Line) to cut the *Meridian* Line at right Angles: This Line shall be the *Equinoctial* Line, and serve to denote the Hour Distances, as the

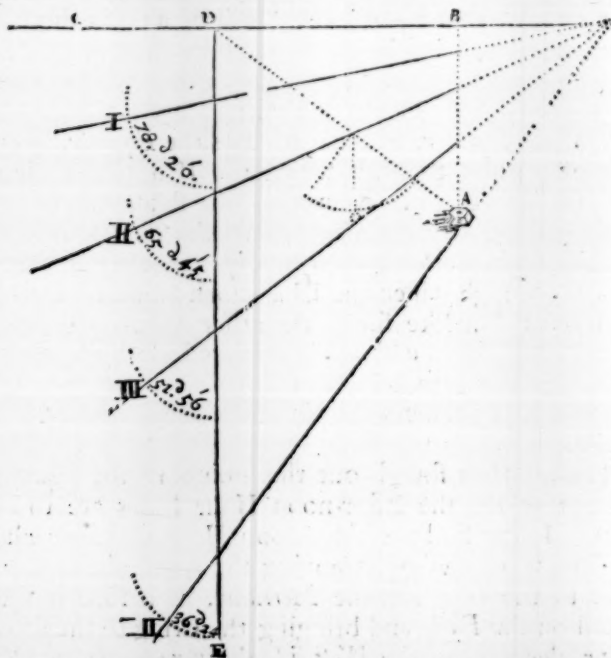
Contin-

*Contingent* Line does on other *Dyals*, as you have often seen.

Then I place the Center of the *Quadrant* on the *Clinatory* upon *Nodus*, so as the Arch of the *Quadrant* may be on the *East* side the *Meridian* Line, and underprop it so, that the flat side of the *Quadrant* may lie parallel to the string, when it is strained between the *Nodus* and the *Equinoctial*, and also so as the string may lie on the Semi-diameter of the *Quadrant*, when it is held up to the *Meridian* Line on the Ceiling. Then removing the string the space of 15 degrees in the *Quadrant*, and extending it to the *Equator* on the Ceiling, where the string touches the *Equator*, there shall be a point through which the I a Clock Hour line shall be drawn: and removing the string yet 15 degrees further to the Eastwards in the Semi-Circle of Position, and extending it also to the *Equator*, where it touches the *Equator*, there shall be a point through which the II a Clock Hour Line shall be drawn. Removing the string yet 15 degrees further, to the Eastwards in the Semi-Circle of Position, and extending it to the *Equator*, there shall be a point through which the III a Clock Hour Line shall be drawn: The like for all the other After-noon Hour Lines. So oft as the string is removed through 15 degrees on the *Quadrant*, so oft shall it point out the After-noon distances in the *Meridian* Line on the Ceiling.

Having thus found out the points in the *Equator* through which the After-noon Hour Lines are to be drawn, I may find the Fore-noon Hour distances also the same way, *viz.* by removing the Arch of the *Quadrant* to the *West* side the *Meridian*, as before it was placed on the *East*, and bringing the string to the several 15 degrees on the *West* side the *Quadrant*; or else I need only measure the distances of each Hours distance

stance found in the *Equator* from the *Meridian* Line on the Ceiling; for the same number of Hours from XII, have the same distance in the *Equinoctial* Line on the other side the *Meridian*, both before and after-noon: The XI a Clock Hour distance is the same from the *Meridian* Line, with the I a Clock distance on the other side the *Meridian*; the X a Clock distance, the same with the II a Clock distance; the IX with the III, &c. And thus the distances of all the Hour lines are found out on the *Equator*.



Now

Now if the Center of this *Dyal* lay within doors, you might draw lines from the Center through these pricks in the *Equator*, and those Lines should be the Hour lines, as in other *Dyals*: But the Center of this *Dyal* lies without doors in the Air, and therefore not convenient for this purpose: So that for drawing the Hour Lines, you must consider what Angle every Hour Line in an *Horizontal Dyal* makes with the *Meridian*; that is, at what distance in Degrees and Minutes the Hour Lines of an *Horizontal Dyal* cut the *Meridian*; which you may examine, as by *Operat. II.* For an Angle equal to the Complement of the same Angle, must each respective Hour Line with the *Equator* on the Ceiling have.

Thus upon the point markt for each Hour distance in the *Equinoctial Line* on the Ceiling, I describe the Arches I, II, III, IV, as in the Figure, and finding the distance from the *Meridian* of the Hour Lines of an *Horizontal Dyal* to be according to the *Operat. II.* Thus,

$$\begin{array}{l} \text{The } \left. \begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \end{array} \right\} \text{ a clock Hour line } \left. \begin{array}{c} 11.40 \\ 24.15 \\ 38.14 \\ 53.36 \end{array} \right\} \begin{array}{l} \text{whose Com-} \\ \text{plement to} \\ 90 \text{ is} \end{array} \left. \begin{array}{c} 78.20 \\ 65.45 \\ 51.56 \\ 36.24 \end{array} \right\} \end{array}$$

I measure in a *Quadrant* of the same *Radius* with those Arches already drawn from the *Equinoctial Line*

$$\begin{array}{l} \text{for the } \left. \begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \end{array} \right\} \text{ a Clock Hour } \left. \begin{array}{c} 78.20 \\ 65.45 \\ 51.56 \\ 36.24 \end{array} \right\} \end{array}$$

and transfer these distances to the Arches drawn on the Ceiling: For then straight Lines drawn through the  
F 2 mark



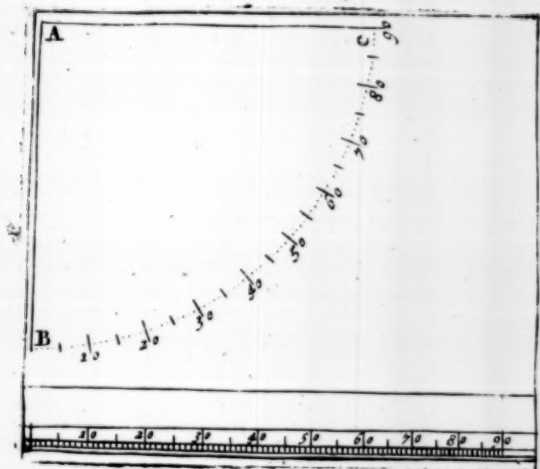
mark in the Arch, and through the mark in the *Equator*, and prolonged both ways to a convenient length, shall be the several Hour Lines (aforesaid;) And when the Sun shines upon the Glass at *Nodus*, its Beams shall reflect upon the Hour of the Day.

*Some helps to a young Dyalist for his more orderly and quick making of Dyals.*

**I**T may prove somewhat difficult to those that are unpractised in *Mathematical* Projections, to devide a Circle into 360 Degrees (or which is all one) a Semi-Circle into 180, or a *Quadrant* into 90 degrees; and though I have taught you in the projecting the *Horizontal Dyal* the original way of doing this, yet you may do it a speedier way by a Line of Chords, which if you will be curious in your Practise, you may make your self; or if you account it not worth your while, you may buy it already made on Box or Brass of most *Mathematical* Instrument-Makers. This Instrument is by them called a *Plain Scale*, which does not only accommodate you with the devisions of a *Quadrant*, but also serves for a Ruler to draw straight Lines with: the manner of making it is as follows.

Describe upon a smooth flat even-grain'd Board a quarter of an whole Circle, as B C, whose *Radius* A B or A C may be four inches, if you intend to make large *Dyals*, or two inches if small; but if you will, you may have several Lines of Chords on your *Scale* or *Rule*. Devide this *Quadrant* into 90 equal parts as you were taught in the making the *Horizontal Dyal*.

Then



Then draw close by the edge of your straight Ruler a Line parallel to the edge, and at about  $\frac{1}{10}$  part of an Inch a second Line parallel to that, and at about  $\frac{1}{8}$  of an Inch a third Line parallel to both. Then place one Foot of your Compasses at the beginning of the first degree on the *Quadrant* described on the Board, as at B, and open the other Foot to the end of the first degree, and transfer that distance upon your Rule, from B to the first mark or deviation, between the two first drawn Lines. Then place one Foot of your Compasses again at the beginning of the first degree on the *Quadrant* described on the Board, as at B, and open the other Foot to the end of the second Degree, and transfer that distance upon your Rule from B to the second mark or deviation between the two first drawn Lines; And thus measure the distance of every Degree from the first Degree described on the *Quadrant*, and transfer it to the Rule. But for distinction sake, you may draw every tenth deviation from the first Line parallel  
to

to the edge of the third Line, and mark them in succession from the beginning with 10, 20, 30, to 90 : and the fifth Devisions you may draw half way between the second and the third parallel Lines; the single Devisions only between the two first parallel Lines. So is your Line of Chords made.

*The Use of the Line of Chords.*

AS its use is very easie, so its convenience is very great ; for placing one Foot of your Compasses at the first Devision on the Scale, and opening the other to the 60<sup>th</sup> Degree, you may with the points of your Compasses (so extended) describe a Circle, and the several Devisions, on the *Scale* shall be the Degrees of the four *Quadrants* of that Circle, as you may try by working backwards, to what you were just now taught in the Making the *Scale* : For as before you measured the distance of the Degrees of the *Quadrant*, and transferr'd them to the *Scale*, so now you only measure the Devisions on the *Scale*, and transfer them to the *Quadrant*, Semi-Circle, or whole Circle described on your Paper. For *Example* :

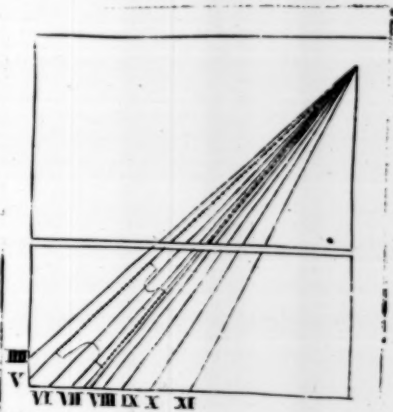
If you would measure 30 Degrees in your described Circle, place one Foot of your Compasses at the beginning of Devisions on the *Scale*, as at A, and extend the other Foot to the Divisions marked 30, and that distance transferred to the Circle, shall be the distance of 30 degrees in that Circle. Do the like for any other number of Degrees.

You may draw your Dyal first on a large sheet of Paper, if your Dyal Plane be so large, if it be not so large, draw it on a smaller piece of Paper ; Then rub the back-side of your Paper-Dyal with Smal-coal, till it  
be

be well black't; and laying your Paper Dyal on your Dyal Plane, so that the East, West, North, or South Lines of your Paper agree exactly with the East, West, North, or South scituation of your Dyal Plane. Then with Wax or Pitch fasten the Corners of the Paper on the Plane, and laying a straight Ruler on the Hour-Lines of your Dyal, draw with the blunted point of a Needle by the side of the Ruler, and the Smal-coal rub'd on the back-side the Paper will leave a mark of the Lines on the Plane.

If you will have the Lines drawn Red, you may rub the back-side of your Paper with *Vermillion*; if Blew, with *Verditer*; if Yellow, with *Orpment*, &c. Then draw upon these marked Lines with Oyl Colours, as you please.

If your Dyal Decline far towards the East or West, the Hour-lines (unless projected to a very great length) will run very close to one another; therefore in this case you must project your Dyal on a large Table, or sometimes on the Floor of a Room, and cut it off as far as you think good, from the Center; for the further from the Center, the larger the distance of the Hour-lines. See the Figure.



An Explanation of some Words of Art used in this  
B O O K.

**A**Ng'le. The meeting or joyning of two Lines.

*Arch.* A part of a Circle.

*Axis.* The straight Line that runs through the Center of a Sphere, and both ways through the Circumference: though in *Dyalling* it is all one with the *Diameter* of a Circle.

*Clinatory.* See Fol. 8, 9, 10.

*Chord.* See Fol. 44, 45, 46.

*Complement.* The number that is wanting to make up another number 90 Degr. or 180 Degr. or 360 Degr. &c.

*Contingent.* A Line crossing the *Substile* at right Angles.

*Degree.* See Fol. 12.

*Diameter.* The longest straight Line that can be contained within a Circle, *viz.* the Line that passes through the Center to the Circumference both ways.

*Dyal Plane.* See Fol. 7.

*Elevation of the Pole.* So many degrees as the *Pole* is elevated above the *Horizon*.

*Equinoctial.* The *Equinoctial* is a great Circle that runs evenly between the two *Poles* of the World. But when we name the *Equinoctial* in this Book, we mean a small Circle which represents it, and is the Circle or Arch of a Circle which is divided into equal parts to find thereby the unequal parts on the *Line of Contingence*. In the *Horizontal Dyal* it is that Arch of a Circle marked G C H.

*Horizon.* Is a great Circle encompassing the place we stand upon; but in *Dyalling* it is represented by a straight Line, as in *Operat. III.* In the *South Dyal* the Line VI A VI is the *Horizontal Line*.

*Lati-*

*Latitude.* The Latitude of a Place is the number of Degrees contained between the *Equinoctial* and the place inquired after.

*Line of Contingence.* See *Contingent*.

*Magnetick Needle.* The Needle touch'd with the *Load-stone*, to make it point to the North.

*Meridian,* is a great Circle of Heaven passing through the North and South points of the *Horizon*; but in Dyalling it is represented by a straight Line, as in *Operat. II.* in the *Horizontal Dyal* the Line XII A is a *Meridian Line*.

*Nadir.* The point directly under our Feet.

*Nautial Compass,* Is the Compass used by *Navigators*, whereon is marked out all the 32 Winds or Points of the Compass.

*Oblique Plane.* See *Fol. 7.*

*Parallel.* See *Fol. 6.*

*Perpendicular.* See *Fol. 5.*

*Pole.* The North or South Points on the Globe of the Earth, are called *North* or *South Pole*.

*Quadrant.* The fourth part of a Circle.

*Radius.* Half the Diameter of a Circle.

*Right Angle.* A straight Line that falls perpendicularly upon another straight Line, makes at the meeting of those two Lines a Right Angle.

*Semi-Circle.* Half a Circle.

*Semi-Diameter,* The same *Radius* is.

*Sphere.* The highest Heaven with all its imagined Circles is called the *Sphere*.

*Stile.* The *Gnomon* or Cock of a Dyal.

*Substile.* The Line the Stile stands on upon a Dyal Plane.

*Triangle.* A figure consisting of 3 Sides and 3 Angles.

*Zenith.* The Point directly over our Head.

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